INTERNATIONAL MARITIME ORGANIZATION

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HARMFUL AQUATIC ORGANISMS IN BALLAST WATER

Information on the type approval of the Van Oord Ballast Water Management System

Submitted by the Netherlands

SUMMARY

Executive summary:	This document provides information on the type approval by the Netherlands of the Van Oord Ballast Water Management System in accordance with the *Guidelines for approval of ballast water management systems (G8)*, in compliance with regulation D-3.1 of the International Convention for the control and management of ships' ballast water and sediments, 2004
Strategic direction:	7.1
High-level action:	7.1.2
Output:	7.1.2.4
Action to be taken:	Paragraph 7
Related documents:	MEPC 65/2/2, MEPC 65/2/9; resolutions MEPC.169(57), MEPC.174(58) and MEPC.228(65)

Introduction

1 Regulation D-3.1 of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 provides that ballast water management systems must be approved by the Administration taking into account the guidelines developed by the Organization.

2 The Van Oord Ballast Water Management System that makes use of drinking water and commercially available chlorine solution was granted Basic and Final Approval at MEPC 65 in accordance with the *Procedure for approval of ballast water management systems that make use of Active Substances* (G9) (resolution MEPC.169(57)).

3 The Netherlands' Administration confirms that the recommendations made by the GESAMP-BWWG have been adequately implemented and the necessary measures regarding ships and human safety have been taken. This is reflected in the new Van Oord Ballast Water Management System Manual, Revision 3.

4 The ballast water management system was evaluated by the Netherlands' Administration in accordance with the *Guidelines for approval of ballast water management systems (G8)* (resolution MEPC.174(58)) and its consistency with technical criteria required by these guidelines was confirmed.

5 Land-based tests were conducted by MEA-nl at den Oever, Netherlands, in April and May 2014, the shipboard tests were conducted in July 2014 in the Netherlands and in October 2014 in Indonesia. A summary of the test results can be found in a copy of the Type Approval Certificate set out in annex 1 to this document.

Information reporting on type approved ballast water management systems

6 In accordance with the *Information reporting on type approved ballast water management systems* (resolution MEPC.228(65)), the Administration of the Netherlands provides the following information for the Organization:

.1 approval date: 19 November 2015;

.2 name of the Administration: Netherlands Shipping Inspectorate, Ministry of Infrastructure and the Environment;

.3 name of the BWMS: Van Oord Ballast Water Management System;

.4 a copy of the Type Approval Certificate is set out in annex 1 to this document;

.5 the test procedure for land-based testing is set out in annex 2; and

.6 the test procedure for shipboard testing is set out in annex 3.

Action requested of the Committee:

7 The Committee is invited to note the information contained in this document.

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ANNEX 1

TYPE APPROVAL CERTIFICATE

The Netherlands

TYPE APPROVAL CERTIFICATE OF BALLAST WATER MANAGEMENT SYSTEM

This is to certify that the Ballast Water Management System listed below has been examined and tested in accordance with the requirements of the specifications contained in the Guidelines contained in IMO resolution MEPC.169(57), G9 and MEPC.174(58), G8. This certificate is valid only for the Ballast Water Management System referred to below.

This certificate is issued to:

Producer:	Van Oord BV
Address:	Schaardijk 211 3063 NH Rotterdam
Under type designation:	Van Oord Ballast Water Management System
Ballast water system manufactured by:	Van Oord Ship management BV
To equipment/assembly drawing:	Van Oord BWM Manual Version 3, dated 15-9-2015
System limitation:	Treated potable water, up to a maximum amount of 450 m^3
Maximum allowable dosage:	5 mg/L TRO (as Cl_2)
Maximum allowable discharge concentration:	0.2 mg/L TRO (as Cl_2)

A copy of this Type Approval Certificate should be carried on board a vessel fitted with this Ballast Water Management System at all times. A copy of the test results and a copy of the Manual should be available for inspection on board the vessel.

Issued at Rotterdam, 19 November 2015, under no. 11430/2015

This certificate remains valid, provided no alterations or modifications are made, until 18 November, 2020.

THE MINISTER OF INFRASTRUCTURE AND THE ENVIRONMENT
On behalf of,
THE UNIT MANAGER CERTIFCATION AND PERMITS,
On behalf of,

K. Hak
Senior surveyor

Enclosures: Ratings, components, and copy of the original test results (4 pages)

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Attachment to certificate of type approval no. .../2015

The Van Oord Ballast Water Management manual V3 has been appraised for compliance with IMO Resolution MEPC.169(57) and forms part of the type approval certificate for the ballast water management system issued to van Oord BV. The system received basic Approval at MEPC 65, according to MEPC 65/22 par. 2.8.

System application:

Ballasting agent	Potable water
Treatment chemicals	Commercially available active chlorine solution
Measurement tools	Chlorine analyser
Neutralisation chemicals	Commercially available Sodium bisulphite

Excerpt from the VO-BWMS manual:

Principle of the Van Oord Ballast Water Management System (VO-BWMS)

The VO-BWMS is designed exclusively for use on board of designated ships of Van Oord B.V. (and her subsidiaries). The use of drinking water as ballast water of this part of the fleet will be limited for various reasons such as the availability (volume and flow rate), quality, costs but also ethical grounds. In addition the lack of a global standard for drinking water does imply that the quality will vary globally. Nevertheless, drinking water is always fresh water, free of sediment, organic particles and organisms larger than 10 micron. The remaining concerns with respect to the quality of drinking water are traces of active substances in those areas where the drinking water is treated with active substances and the (potentially) presence of human pathogens in regions with no effective disinfection process of the drinking water.

System components

Below is a description of the VO-BWMS with the components and normal operation procedures during water intake and discharge.

- Municipal, road tanker, bunker boat or water maker on board
- Disinfecting chemical (commercially available chlorine)
- Auto diagnostic portable microprocessor to check chlorine concentration.
- Chlorine neutralizing agent (sodium bisulphite)
- Ballast discharge pump (as installed on board)

Characteristics of the VO BWMS.

This ballast water management system is meant to be for a limited part of the Van Oord fleet with a low total ballast water capacity and particularly a very low ballast frequency. Proper and correct operation of the system can be guaranteed by limiting the involved technology, proper work instructions and procedures and mobilizing good workmanship of the crew by foreseeing regular training how to use and maintain the system. Even when the system is occasionally used due to the low ballast frequency of the vessel, full functionality of the Van Oord BWMS can be guaranteed.

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Summary of the land based and shipboard test results

- The land based testing was conducted by MEA-NL at den Oever, Netherlands. The summary of the land based test results was taken from the test report by MEA-NL (report 1503-LB dated April 2015)
- The shipboard testing was conducted by MEA-NL. The summary of the shipboard test results was taken from the test report by MEA_NL (report 1502-SB dated June 2015)
- Not all samples were taken in triplicate, see the reports 1502-SB and 1503-LB for details
- Indicator microbes were analysed by accredited laboratories (Vitens in the Netherlands and Setsco in Singapore)
- Organisms <50µm were determined by flow cytometry and PAM fluorometry
- Organisms ≥50µm were determined by inverted microscopy.

Land based test summary:

From April 30th until May 10th 2014, the VO-BWMS was tested using potable water in the harbour of Den Oever (the Netherlands). The BWM system is based on manual addition of an active chlorine solution in combination with a neutralisation agent administered prior to discharge. Because of the characteristics of the intake water several of the minimum required intake parameters according to the IMO Guidelines G8 were not relevant. This included TSS, POC, DOC but also the requirement with tests of water differing in salinity.

With respect to the biotic parameters number of organisms in the size class larger or equal to 50 micron and the size class of larger or equal to 10 micron but smaller than 50 micron in dimension did not meet the criteria for intake as indicated in the Guidelines G8.

The treatment was effective in all relevant size classes of organisms after a holding period of five days resulting in the absence of viable organisms in the discharge water. Upon discharge the numbers of organisms were often 0 per discrete volume and therefore always substantially below standard of Regulation-D2 of the IMO Ballast Water Management Convention. Although this also included the human pathogens it should be noted that these indicator organisms were absent in the challenge water straight at the intake.

In conclusion the present land-based test results of the VO-BWMS demonstrate that their management technology meets the Regulation D-2 of the IMO BWM Convention (Article 2). This regulation aims to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ship's Ballast Water and Sediments.

Shipboard test summary:

The ship-board tests were separated in two sets of activities. The first one was a single test run, conducted on board of the MPV "Jan Steen", while sailing in the coastal zone of the Netherlands (11th - 22th of July 2014). The source water used was originally North Sea water with a high salinity. The water maker of the MPV "Jan Steen" produced from the seawater challenge (potable) water, which was used as ballast water.
The second test series included three test runs and were all carried out on board of the flat top barge "Guavina" in Batam (Indonesia, 22th - 29th October 2014). The challenge water used during these test runs was potable water transported by a bunker boat.

The challenge water in all test runs did already meet the criteria for discharge as indicated in Regulation D-2 of the IMO BWM Convention. In those test runs viable organisms were present in the challenge water the treatment of the VO-BWMS further

reduced the number of viable organisms. This was already observed at intake immediately after addition of the disinfection agent (chlorine). Upon discharge the number of viable organisms was often 0 per discrete volume and therefore always substantially below the standard of Regulation-D2 of the IMO Ballast Water Management Convention (IMO, 2004). Although this also included the human pathogens it should be noted that no conclusions can be made due to the fact that these indicator organisms were absent in the challenge water at intake.

Based on the results of the VO-BWMS it can be concluded that their BWM System meets the Regulation-D-2 of the IMO BWM Convention (Article 2).

Summary of the test results:

Land-based summary table potable water tests
Tests have been conducted with municipal drinking water from the town of Den Oever, the Netherlands

IMO size class/category	sample type	test run I	test run II	test run III
≥50 micron [number/m^3]	intake	0	0	0
	discharge control	0	0	0
	discharge treated	0	0	0
≥10 and < 50 micron [number/ml]	intake	0	0	0
	discharge control	0	0	0
	discharge treated	0	0	0
heterotrophic bacteria [cfu/ml]	intake	7900	6500	
	discharge control	360000	190000	
	discharge treated	6900	400	40
E. coli [cfu/100 ml]	intake	<1	<1	<1
	discharge control	<1	<1	<1
	discharge treated	<1	<1	<1
enterococci [cfu/100 ml]	intake	<1	8	
	discharge control	<1	<1	
	discharge treated	30	<1	
Vibrio cholerae [cfu/100 ml]	intake	nd	nd	nd
	discharge control	nd	nd	nd
	discharge treated	nd	nd	nd

nd: no data

land-based: physical and chemical parameters

parameter	salinity [PSU]	temperature [°C]	pH	TSS [mg/l]	POC [mg/l]
range 3 test runs	0.2-0.3	12.1-12.5	6.5-6.8	0.4-1.4	0.3-0.7

flow rate intake: 10-18 m^3/h

Shipboard summary potable water tests

tests have been conducted with water maker onboard of a ship (test run I) and potable water from water boat (test runs II-IV)

IMO size class/category	sample type	test run I	test run II	test run III	test run IV
≥50 micron [number/m^3]	intake	0	18	9	14
	discharge control	nd	nd	nd	nd
	discharge treated	0	0.5	0	0
≥10 and < 50 micron [number/ml]	intake	1	0	0	0
	discharge control	13	0	0.8	0
	discharge treated	0	0	0	0
heterotrophic bacteria [cfu/ml]	intake	nd	5200	200	1700
	discharge control	nd	4700	76000	5200
	discharge treated	nd	2000	530	1600
E. coli [cfu/100 ml]	intake	<1	24	12	4
	discharge control	<1	<1	<1	<1
	discharge treated	<1	<1	<1	<1
enterococci [cfu/100 ml]	intake	<1	<1	<1	<1
	discharge control	<1	<1	<1	<1
	discharge treated	<1	<1	<1	<1
Vibrio cholerae [cfu/100 ml]	intake	nd	<1	<1	<1
	discharge control	nd	<1	<1	<1
	discharge treated	nd	<1	<1	<1

nd: no data

shipboard: physical and chemical parameters

parameter	salinity [PSU]	temperature [°C]	pH	TSS [mg/l]	POC [mg/l]
test run I	0.3	25.4	8.5	0.3	0.4
average test runs II-IV	0	29.9	7.0	2.9	1.0

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ANNEX 2

TEST PROCEDURE FOR LAND-BASED TESTING

5. Test procedure

The methods applied are described in detail in the test protocol as approved by the National Administration (MEA, 2014).

IMO Guidelines G8 (IMO, 2008b) require, for land-based tests two series of five test runs at two different salinity regimes, to verify the biological efficacy and environmental acceptability of a BWMS. The approval testing aims to ensure replicability and comparability to other treatment equipment. The minimum holding time for a full test is five days.

5.1 Challenge water conditions

The challenge water has to meet several minimum conditions as to physical, chemical and biological composition.

As to physical and chemical conditions, the requirements are given in **table 2**. Requirements for biological condition are given in **table 3**.

Table 2: Salinity ranges and minimum concentrations of TSS, POC, and DOC [mg/l] in the challenge water

	Salinity		
	> 32 PSU	3 – 32 PSU	< 3 PSU
Dissolved Organic Carbon (DOC)	> 1 mg/l	> 5 mg/l	> 5 mg/l
Particulate Organic Carbon (POC)	> 1 mg/l	> 5 mg/l	> 5 mg/l
Total Suspended Solids (TSS)	> 1 mg/l	> 50 mg/l	> 50 mg/l

Table 3: Minimum numbers of organisms and species required

	Challenge water	
	Unit	Remarks
Organisms ≥ 50 micron	$> 10^5/m^3$	At least 5 species from at least 3 different phyla/ divisions
10 ≤ organism size ≤ 50 micron	$> 10^3$/ml	At least 5 species from at least 3 different phyla/ divisions
< 10 micron[1]	n.a.	
Heterotrophic bacteria	$> 10^4$/ml	Not further defined

[1]: For completeness, a quantification of the planktonic fraction (phytoplankton and other protists < 10 µm) is also included in the tests programme conducted by MEA-nl.

Although no specific requirements for challenge water are given for the following bacteria, the following should be measured at intake and discharge:

1. *E. coli*
2. Enterococcus group
3. *Vibrio cholerae*; and
4. Heterotrophic bacteria

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5.2 Requirements for sampling and analysis

Guideline G8 (IMO, 2008b) identifies a set of parameters to be sampled. The related sample volumes and methods as per best practice and according to the Standard Operating Procedures (SOP) are given in **table 4**. Analytical methods according to SOPs are given in **table 5**.

Table 4: List of core parameters, sample volumes and operational conditions

Parameter	Volume IMO	MEA-INNOVATOR
Salinity, TSS, POC, MM, DOC, DO, pH, temperature, turbidity (standard parameters)	10 l	Bucket samples (10 l) taken in triplicate, evenly distributed over the whole sampling period; sample size varies depending on particle load (SOP-306)
Inorganic nutrients		N, P and Si directly from bucket sample (SOP-308)
10 ≤ organism size < 50 micron	1 l	Samples taken in triplicate at the same time as the standard parameters (1 l) (SOP-317, 318 & 319)
Heterotrophic bacteria	500 ml	Samples taken in triplicate at the same time as standard parameters (1 l) (SOP-316)
Organisms < 10 micron	n.a.	Samples taken in triplicate at the same time as standard parameters (1 l) (SOP-322)
Organism size ≥ 50 micron; treated water	1 m^3	Subsampling; sample volume was at least 500 l (SOP-320)
Organism size ≥ 50 micron; control water	20 l	Bucket samples of 20 l each, at the same time as the standard parameters (SOP-320)

All samples will be given a unique number, referring to the source and time according to the applicable SOP.

Table 5: Analyses with their associated measurement standard, equipment and MEA-nl SOP-number

On site (laboratory MEA-INNOVATOR)	SOP MEA-nl	Equipment/standard
Salinity, temperature, pH, dissolved oxygen and turbidity	SOP-306	Handheld meter (Palintest Macro 900)
Organisms < 10 µm phytoplankton	SOP-322	Flow cytometry
Organisms 10 – 50 µm	SOP-317	Flow cytometry
Organisms 10 – 50 µm	SOP-318	PAM-fluorometry
Organisms > 50 µm	SOP-320	Microscopy
Incubation experiments	SOP-326	Flow cytometry/ PAM-fluorometry
Organisms < 10 µm bacteria	SOP-316	Flow cytometry
Off site (laboratory MEA-nl)		
Organisms 10-50 µm Microscopy	SOP-319	Inverted Microscopy
TSS/POC and MM (filtration will be on site)	SOP-309	Filtration
External		
Human Pathogens	SOP-311	ISO-7899-2, ISO 9308-1
Dissolved nutrients (nitrogen, phosphate, silicate)	SOP-308	Internal based on international standards
Dissolved Organic Carbon (DOC)	SOP-308	NEN-EN 1484

5.3 Sampling time line

At intake (t0), two tanks are filled simultaneously with challenge water. One of the tanks contains control water; the other tank holds treated water. After five days (t5), water is discharged: control water directly overboard and treated water after final treatment (neutralisation). **Figure 4** represents the sampling time-line accordingly.

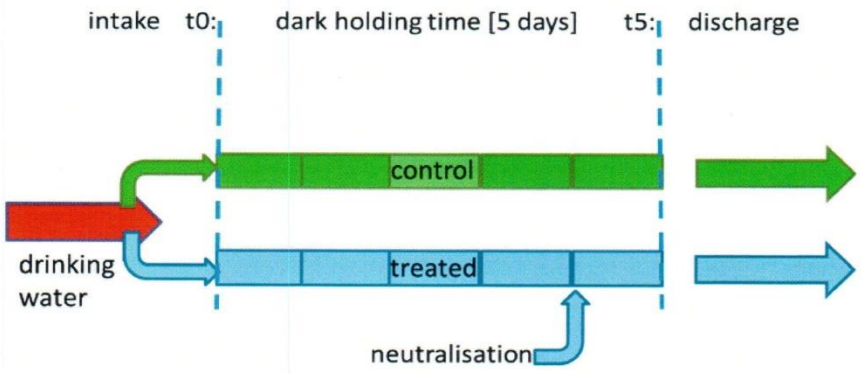

Figure 4: Schematic overview of the time line during a test run

At intake (t0) two tanks were filled by use of a fire hose , see also **figure 5**:

1. One tank with control water
2. One tank with treated water where chlorine was added manually (max concentration of 5 mg/l)

At day 4 the remaining chlorine concentration was neutralised, using sodium bisulphite. At day five (t5), both tanks were discharged. See also **figure 6**.

To test the efficiency of the treatment at discharge, a subsample of 10 litre water was incubated under optimal growth conditions to stimulate phytoplankton growth in particular.

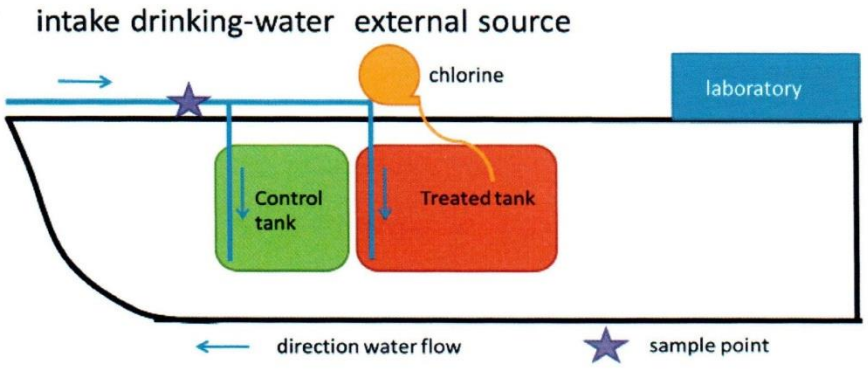

Figure 5: Schematic overview at intake including sample points

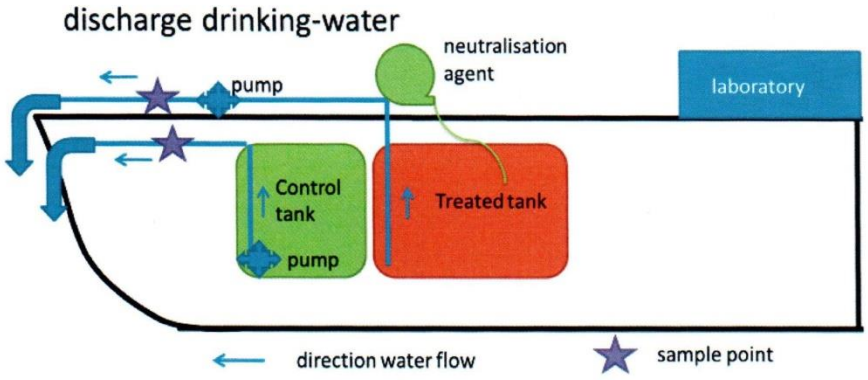

Figure 6: Schematic overview at discharge, including sample points

5.4 Test protocol and QAPP

MEA-nl governs her processes and data by means of a quality management system, certified in accordance with the requirements of ISO-9001:2008. Scope of the certification is:

To perform tests for certification of ballast water management systems

A certificate has been issued by the United Kingdom Accreditation Service (UKAS), as audited by Lloyd's Register Quality Assurance.

All analyses done at external laboratories are in accordance with the same quality standards. The present management system will be upgraded to a more specific standard, ISO-17025.

The test protocol (MEA, 2014) is the Quality Assurance Project Plan (QAPP) for verification tests. Standard Operating Procedure (SOP) are part of our Quality Management System and assure transparency, reproducibility and consistency of the operational activities. All methods are based on validated scientific procedures.

All raw data and test results are checked, recorded and stored according to the relevant SOP's.

To underpin the reliability of data, non-conformities, including deviations and out of specs, are recorded.

5.5 Deviations from Guidelines G8 and amendments

Due to the character of potable water (low salinity, free from organisms and pathogens) and for conservation of valuable resources, it was agreed to conduct only three instead of five test runs, as approved by the National Administration of The Netherlands.

As a consequence of the properties of the challenge water, minimum intake criteria could not be met for all parameters. These deviations are described in the test protocol (MEA, 2014).

Due to the properties of the ships that might use the system (max. 450 m^3 ballast water capacity) in order to meet the conservation criteria, a maximum of treatment volume of 100 m^3 was agreed for testing purposes.

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ANNEX 3

TEST PROCEDURE FOR SHIPBOARD TESTING

5. Test procedure

For details of the test procedure see Test Protocol for the verification of the shipboard test of the Van Oord BWM system (MEA, 2014)
The present ship board tests included two series of test runs. The first set included one test run on board of the MPV "Jan Steen" using the water maker as the primary source of ballast water (the Netherlands). The second series of three test runs was conducted in Batam (Indonesia). During these tests drinking water was supplied by a bunker boat. This water originated from the local water supply in Batam.

5.1 Description of the MPV "Jan Steen", water maker

The MPV "Jan Steen" (IMO number 850707, for details see chapter 8.8 (**figure 3**)) is an offshore support vessel of the fleet of Van Oord and was employed during the ship board test to transport bed-rocks to an offshore wind park just outside the coast of IJmuiden (the Netherlands).

Figure 3: MPV "Jan Steen"

On board of the 'Jan Steen' ballast water was produced by a Promac Aquaset type MAR18S ECV, reverse osmoses unit with a capacity of 16-18 m^3/24 h.

Figure 4: RO unit Promac Aquaset

Figure 5: Inside view of ballast tank 5

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On board of the MPV "Jan Steen" the double bottom ballast tank number five (**figure 5**) was cleaned prior to the test and filled with drinking water directly from the reverse osmoses unit (**figure 4**). This was done during normal operation of the ship which was initially limited to the periods of transit in open sea. This limited the quantity of produced osmose water. Filling of tank number five started at July 11th and finished at July 16th. Due to the low quantity of water production of the osmose unit, it was decided to have the osmose unit operated continuously, even in the brackish and more turbid water harbour of IJmuiden.

On July 17th a total volume of 44 m^3 of ballast water was produced. Sodium hypochlorite (3 l of 12.5 % stock solution) was added to a final concentration of 5 mg Cl_2/l. One IBC tank of 1 m^3 was filled with the same reverse osmose water but without further treatment and acted as the control.

On July 21th the remaining chlorine in the tank was neutralised with 2 litre RO bisulphite of 38 – 40% stock solution. Water of tank five was discharged the following day in the harbour of IJmuiden using the ships ballast water pump. Samples for the analysis of relevant parameters were taken as prescribed in the test protocol. The discharge procedure was audited by Mr K. Hak of the Dutch Human Environment and Transport Inspectorate (IL&T, chapter 8.10).

5.2 Description of the barge "Guavina", bunker boat

In addition to municipal water and ballast water produced with a water maker, also water supplied by a bunker boat was tested. These tests were carried out in a tropical region, to examine the effect of high temperatures on the performance of the Van Oord BWM System. The tests were conducted at the Panda Bahari shipyard in Batam (Indonesia). The deck top barge GUAVINA was used as a test platform.

Ship's particulars:

Ship's name	GUAVINA	
Ship type	Deck Cargo Barge	
IMO number	-	
Built	-	
Flag	the Netherlands	
LOA	36.6 m	
Breath MLD	B	12.2 m
Depth MLD	D	2.4 m

Six separate holding tanks, a volume of ca 100 m^3 each

Ship Manager Van Oord, the Netherlands

For details of the flat top barge "GUAVINA" see chapter 8.9

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The dedicated ballast water tanks were cleaned prior to the test runs. Although clean they were still rusty. The three PS tanks acted as the control tank and the three SB tanks were used as treated tanks. Drinking water for the three test runs was supplied by a bunker boat (**figure 6**). This was done at three consecutive days from the 22th of October until the 24th of October 2014.

First, the to be treated tank was filled with 40 m^3 or more water. The remaining water left in the bunker boat was used as control water and pumped into a second holding tank. Exact volumes used were determined based on records of the totalizer of the inline flow meter of the bunker boat. Based on the volume of water loaded for treatment, commercially available chlorine was added manually and mixed by a submersible pump in closed circuit (**figure 7**). Samples were taken immediately for further analysis at the premises of the ship yard. A subset of samples for the analysis of the human pathogens was sent to the certified laboratory (SETSCO, Singapore). Other samples were preserved and frozen for further analysis in the laboratory of MEA-nl.

Figure 6: Bunker boat at the Batam test site

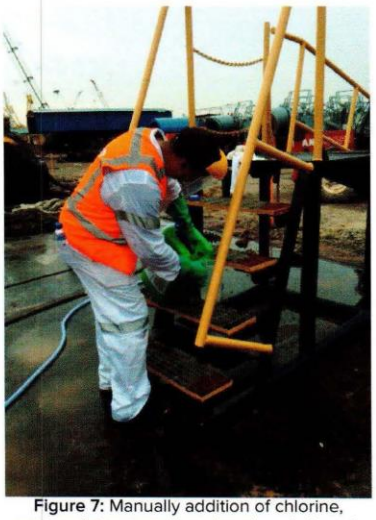

Figure 7: Manually addition of chlorine, note safety precautions (mask and gloves)

After chlorine measurement for possible neutralisation needed, discharge was done after a holding period of five days using a submersible pump (October 27th – 29th). The last discharge procedure (October 29th) was witnessed by Mr. K. Herwindo of Bureau Veritas (Indonesia, location Batam, chapter 8.11).

5.3 Requirement for sampling and analysis

The Guidelines G8 (IMO, 2008b, section 2.2.2.9) identified with respect to ship-board verification tests a set of samples to be measured (**table 2**). The following core parameters are required and were therefore sampled and analysed accordingly at intake and discharge: salinity, temperature, TSS and POC. In addition also DO, pH, turbidity and DOC were measured (**table 2**).

Table 2: List of parameters and sample volumes and operational conditions

Parameter	Volume IMO	MEA-nl
salinity, temperature, pH, TSS, POC, DOC, DO, turbidity	10 l	In triple 10 l bucket samples evenly distributed over the whole sampling period; sample size varies depending on particle load (SOP-306)
10 ≤ organism size < 50 micron	10 l	samples taken in triplicate at the same time as the standard parameters (1 l) (SOP-317, 318 & 319)
heterotrophic bacteria	500 ml	samples taken in triplicate at the same time as standard parameters (1 l) (SOP-316)
organisms < 10 micron	n.a.	samples taken in triplicate at the same time as standard parameters (1 l) (SOP-322)
organism size ≥ 50 micron; treated water	1 m^3	Continuous subsampling sample volume was at least 500 l. (SOP-320)
organism size ≥ 50 micron; control water	20- 1000 l	Bucket samples of 20 l each or IBC, at the same time as the standard parameters (SOP-320)

Analytical methods according to the SOPs of MEA-nl are given in **table 3**. Not all samples for abiotic and biotic measurements were taken in triplicate at intake and discharge; samples for salinity, turbidity, pH, DO and the organism's ≥ 50 micron in minimum dimension were taken at least once.

Table 3: Analyses with their associated measurement standard, equipment and MEA-nl SOP-number

	SOP MEA-nl	Equipment/standard
Salinity, temperature, pH, dissolved oxygen and turbidity	SOP-306	Handheld meter (Palintest Macro 900)
Organisms < 10 µm phytoplankton	SOP-322	Flow cytometry
Organisms 10 – 50 µm	SOP-317	Flow cytometry
Organisms 10 – 50 µm	SOP-318	PAM-fluorometry
Organisms > 50 µm	SOP-320	Microscopy
Organisms < 10 µm bacteria	SOP-316	Flow cytometry
Organisms 10-50 µm Microscopy	SOP-319	Inverted Microscopy
TSS/POC and MM (filtration will be on site)	SOP-309	Filtration
External		
Human Pathogens and heterotrophic bacteria	SOP-311	VITENS:ISO-7899-2, ISO 9308-1, SETSCO: ISO8199, APHA 9222G, APHA 9230C, APHA9260H
Dissolved nutrients (nitrogen, phosphate, silicate)	SOP-308	Internal based on international standards
Dissolved Organic Carbon (DOC)	SOP-308	NEN-EN 1484

The presence of the relevant indicator microbes, which were the human pathogens, E. coli and enterococci and *Vibrio cholerae*, was determined during all four test runs at intake and discharge by accredited laboratories (VITENS B.V. and SETSCO Services Pte Ltd). *Vibrio cholerae* was determined only during the test runs SII until SIV.

With respect to ship-board verification tests the minimal numerical abundance for the different size classes of organisms at intake in the challenge water is indicated in **table 4**.

Table 4: Minimum number of organisms required at intake for different size classes of organisms

Challenge water	
Parameter	unit
organisms ≥ 50 micron	> 100/ m^3
10 ≤ organism size < 50 micron	> 100 / ml

The minimum criteria as indicated in **table 4** were not relevant for the present test series, where potable water was the only source of challenge water. Nevertheless, all parameters were measured although not always in the required number of three replicates.

5.4 Sampling time line

Test run SI was conducted at the MPV "Jan Steen" and three other test runs at the flat top barge "Guavina" in Batam (Indonesia). Despite the capacity the water maker on board of the MPV "Jan Steen" it was initially only used in open water but was operating at a later time continuously to complete the volume of 44 m^3 (**table 5**).

Table 5: Time table giving intake and discharge of the three test runs, volume of water used for control and treated water, flow rates at intake and discharge

Test run	Intake	Discharge	Volume intake m^3	Flow rate intake m^3/h	Flow rate discharge m^3/h
SI-water maker	11-7 / - 16-7-2014	22-7-2014	44	varying and infrequent	90 - 110
SII-bunker boat	22/10-2014	27/10-2014	40	60	150
SIII-bunker boat	23/10-2014	28/10-2014	40	60	150
SIV-bunker boat	24/10-2014	29/10-2014	40	60	150

An overview of the sampling time line for a full scale test run is presented in **figure 8**. As control, a volume of 1 m^3 of challenge water was used for test run SI and 30 m^3 for the tests runs SII until SIV.

The filling of the treated tank for series SI lasted six days to reach the required minimum volume. The holding period after the addition of chlorine was five days. Intake of challenge water of test runs SII until SIV was done within two hours. For all test runs chlorine was added manually in the holding tanks with treated water to a maximum concentration of 5 mg Cl_2 /l. When needed, the remaining chlorine concentration was neutralised with sodium bisulphite at day four. The water was stored for five days (in the dark) prior to discharge at day five (t5) into the aquatic environment.

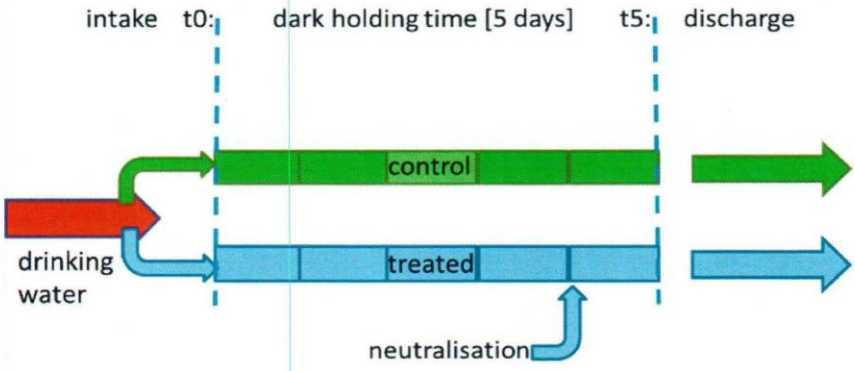

Figure 8: Schematic overview of the time line during a test run

5.5 QAPP

MEA-nl governs her processes and data by means of a quality management system, certified in accordance with the requirements of ISO-9001:2008. Scope of the certification is:

To perform tests for certification of ballast water management systems

A certificate has been issued by the United Kingdom Accreditation Service (UKAS), as audited by Lloyd's Register Quality Assurance.

All analyses done at external laboratories are in accordance with the same quality standards. The present management system will be upgraded to a more specific standard, ISO-17025.

The test protocol (MEA, 2014) is the Quality Assurance Project Plan (QAPP) for verification tests. Standard Operating Procedures (SOP) are part of our Quality Management System and assure transparency, reproducibility and consistency of the operational activities. All methods are based on validated scientific procedures.

All raw data and test results are checked, recorded and stored according to the relevant SOPs.

To underpin the reliability of data, non-conformities, including deviations and out of specs, are recorded.

5.6 Deviations and amendments

MPV "Jan Steen": test run SI

The filling of the ballast water tank with drinking water from the water maker took longer than expected (5 days). This was due to the fact that the water maker was only used to produce drinking water during transit to and from the harbour. As a result the quantity of water produced was limited per voyage. At day 4 is was decided to keep the water maker continuously running to assure that the required volume of water for the test was met.

Samples of the different parameters were taken at different times prior to the addition of chlorine. With respect to various (a)biotic parameters the number of samples was limited because of the unique character of the intake water used. Details are indicated in the test protocol (MEA-nl, 2014).

Flat top barge "Guavina"(Batam): test runs SII, SIII and SIV

The three test runs on-board of "Guavina" were modified for the following parameters: Temperature, which normally measured by the Palintests of MEA-nl. Due to delayed calibration by the manufacturer of the measuring devices were not available. Other equipment is used for direct temperature measurement.

The main discharge of ballast water was conducted with a large submersible pump. The water samples for the analysis of the abiotic samples were taken with a small submersible pump at discrete intervals covering the whole discharge period.

Salinity, dissolved oxygen, pH and turbidity were measured in combined samples because of the small water volume available. These measurements were conducted in the laboratory of MEA-nl in the Netherlands.

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